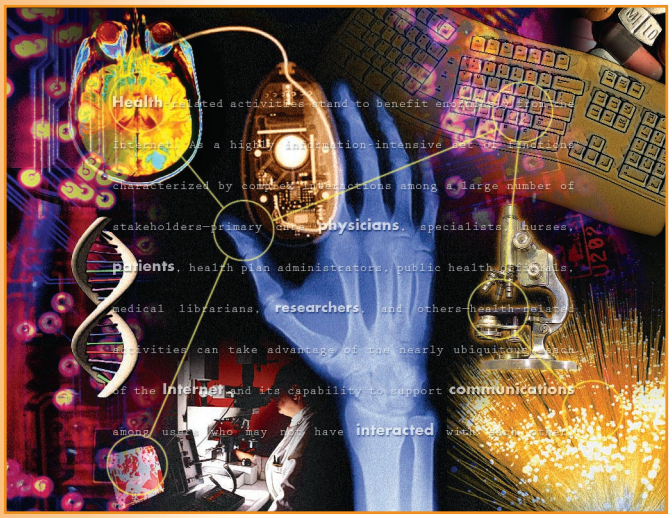

Medicine on the Net

From Isolation to Universal Connectivity

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Medical skill has always been scarce. Originally, it was available only to those who could arrange to be with a practitioner. But technology has, over the past 170 years, provided successively better ways of providing medical service despite separation in time and space. The Internet, personal computers, wireless devices, high-resolution graphic displays, and similar technologies are just the current step in a process of distributed medicine that started with the telegraph.

Perhaps the most dramatic public example of telemedicine dates to the early space program. Forty years ago, astronauts strapped on biosensors, climbed into spacesuits, and headed into orbit, confident that their health would be monitored and any problems radioed to earthbound doctors. Back at the NASA Johnson Space Center, medical personnel tracked the astronauts' vital signs.

Of course, not everyone can arrange to have NASA monitoring his or her health. Using computers to bring medical skill to places without the right personnel has been a goal at least since the time of Project Mercury. It is worthwhile to contrast the shift in attitudes from then to now. In the 1960s, contemporary with the work that led to the Arpanet, researchers at institutions like Stanford, MIT, and Rutgers were creating medical *expert systems*, computer programs that performed tasks such as diagnosing ailments and recommending therapy, given patient and laboratory test data.

Today, some medical systems incorporate intelligent elements intellectually descended from that work. However, as in much of computer science, communication has come to dominate computation. The leading-edge frontier of medical applications is applying network technologies to bridge distances. A patient needing remote expertise is far more likely to get it by telecommunications technology (for example, http://www.med.stanford.edu/telemed/intro.html) than by an expert system.

By providing universal connectivity, satellite technology fostered the growth of telemedicine applications. The Internet adds the bandwidth required for rich interactions (such as transmitting pictures, visual motion, and even the beginnings of haptic response); the multiplicity of connection to allow collaboration among many distributed participants; and the data connectivity to enable access to information in elaborate, distributed histories.

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The Articles

Broadly, the Internet can be applied to medicine in two categories:

- Medical informatics (that is, the secure exchange of medical information)
- Clinical applications (for example, remote diagnosis and patient monitoring)

Both types of applications are represented in this issue.

Our first article, "Bringing Health-Care Applications to the Internet" by Bruce Davie et al., is a summary of a report from the U.S. National Research Council that examines the issues involved in using the Internet to support health-care applications. Key points identified in the article include networking requirements (bandwidth, network availability, ubiquity, latency, and security) and technical challenges (quality of service, security, and broadband technologies). Although individually these issues show up in many domains, medical applications have particular challenges, including many high-bandwidth, real-time applications, and unique security requirements.

Security of data in medical applications is particularly important because the data is health critical. Medical information security is particularly complex because patient data is typically fragmented, controlled by whoever provided health services. While there are clear benefits to maintaining patient records in a central database accessible by the patients' authorized health-care providers, hypothesizing such a system is politically naïve. To complicate matters, the security mechanism must be arranged so that users can quickly share information in the event of an emergency, and emergencies are routine. But how can we ensure that only authorized users can access the charts? Or that both users and providers are who they say they are?

In "Sharing Health-Care Records over the Internet," Grimson et al. describe two systems that leverage Internet and Web technologies to provide a generic approach to shared electronic records. The initial project, Synapses, constructed a Federated Healthcare Record (FHCR) server, which provides integrated access to Electronic Healthcare Records — structured multimedia collections of health-care data about individual patients. Synapses's successor, SynEx, integrates the FHCR server with other components to create a distributed database system of patient records.

Of course, not all medical information is in organized schemas. A critical element of the patient record is a physician's notes, and little is as unlike a relational database row as a doctor's scrawl. Typically, these notes must be transcribed and entered into patient records for them to be easily accessed later. In "The Careflow Architecture: A Case Study in Medical Transcription," V. "Juggy" Jagannathan describes the evolution of a medical transcription system from a university research project to a commercial product. Careflow uses a CORBA-component–based, open-middleware architecture as a scalable, flexible, and secure basis for information interchange among information sources and applications.

The use of the Internet for clinical applications is illustrated by our final article. The earliest telemedicine applications involved transferring diagnostic information, like x-rays and MRIs, and monitoring patients with chronic diseases. But higher bandwidths promise richer interactions. In "Collaborative Surgical Simulation over the Internet," Kim et al. describe a 3D surgical simulation system that allows specialists to collaborate remotely on treatment plans. Their system, Co-Surgeon, uses token control (the user with the token is the one allowed to modify the model) and event exchange (simulation event broadcast to all other clients) to support synchronous and asynchronous surgical simulation and a multilayered collaboration tree to manage stored surgical procedures.

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Resources in Telemedicine

Organizations

Integrated Advanced Information Management Systems (IAIMS) Consortium • http://www.urmc.rochester.edu/iaims/consortium/welcome.html
International Medical Informatics Association (IMIA) • http://www.imia.org
Society for the Internet in Medicine • http://www.internet-in-medicine.org
Telemedicine Information Exchange (TIE) • http://tie.telemed.org

Standards

CORBAMed • http://cgi.omg.org/corbamed/
Digital Imaging and Communications in Medicine (DICOM) • http://medical.nema.org/dicom.html
Health Level Seven (HL7) • http://www.hl7.org
Integrating the Healthcare Enterprise Initiative • http://www.rsna.org/IHE/